

1

## SURFACE CONNECTOR WITH SILICONE SPRING MEMBER

### BACKGROUND

The number of types of electronic devices that are commercially available has increased tremendously the past few years and the rate of introduction of new devices shows no signs of abating. Devices, such as tablet, laptop, netbook, desktop, and all-in-one computers, cell, smart, and media phones, storage devices, portable media players, navigation systems, monitors, and others, have become ubiquitous.

Power and data may be provided from one device to another over cables that may include one or more wire conductors, fiber optic cables, or other conductor. Connector inserts may be located at each end of these cables and may be inserted into connector receptacles in the communicating or power transferring devices. In other systems, contacts on the devices may come into direct contact with each other without the need for intervening cables.

In systems where contacts on two electronic devices come into contact with each other, it may be difficult to generate enough normal force to ensure a good electrical connections between contacts in the two devices. To provide a sufficient normal force, contacts may often have a substantial depth and consume a relatively large volume of space in the electronic device. The loss of this space may mean that the electronic device is either larger or only includes a reduced set of functionality.

Connector systems in general may inadvertently provide paths for the ingress of moisture, liquids, or other fluids. These connector systems may also provide pathways whereby external dust or particulate matter may reach an interior of an electronic device.

Thus, what is needed are contact structures for devices, where contacts in the contact structures provide a proper normal force while consuming a minimal amount of surface area, depth, and volume in a device and where the contact structures prevent or limit the ingress of fluid or debris into the device.

### SUMMARY

Accordingly, embodiments of the present invention may provide contact structures for devices, where contacts in the contact structures provide a proper normal force while consuming a minimal amount of surface area, depth, and volume in a device and where the contact structures prevent or limit the ingress of fluid or debris into the device.

An illustrative embodiment of the present invention may provide a contact structure having a frame. The frame may be arranged to be placed in an opening in a device enclosure for an electronic device or the frame may be part of the electronic device. The frame may include a number of passages, each passage for a contact of the contact structure. Each contact may be held to the frame by a pliable membrane. Each contact may connect to a board in the electronic device via a compliant conductive path.

In these and other embodiments of the present invention, the frame may be formed of a liquid crystal polymer (LCP), glass-filled nylon, aluminum, ceramic, or other material. The pliable membrane may be formed of silicone, rubber, or other pliable material. The pliable membrane may be formed by insert molding or other appropriate method. At least one of the frame or pliable membrane may be nonconductive. The contacts may be copper, stainless steel, or other conductive material. The contacts may be circular, oval, square,

2

or they may have another shape. The contacts may be formed by machining, stamping, or other appropriate method. The compliant conductive path may be a wire, spring, spring-loaded contact, and may be formed using copper, a copper-nickel alloy such as NKC388, or other material.

The contacts may be fixed in position in passages in the frames in various ways. In an illustrative embodiment of the present invention, a contact may be formed as a disk, where a circular outside edge of the disk is supported by a pliant membrane. The disk may have a notch in the circular edge. The pliant membrane may have a corresponding tab that fits into the notch in the side of the disk. In these and other embodiments of the present invention, the frame may have a similar notch in each passage and the pliant membrane may have a second tab fit into the frame notch. This arrangement may secure the contact to the frame and prevent the contact from being pushed out of the frame when contact is made with a second contact on a second electronic device. This arrangement may provide contacts having a minimal depth. These contacts may also consume a limited amount of surface area. The volume in a device that is consumed by these contacts may thus be limited.

The contacts may be fixed in position in passages in the frames in other ways as well. For example, a contact may have a wider top and a narrower lower or base portion. This may simplify manufacturing of the contact. The contact may then be held in place with a pliant membrane that has a narrower top portion and a wider base. The wider base may secure the contact to the frame and prevent the contact from being pushed out of the frame when contact is made with a second contact on a second electronic device.

In various embodiments of the present invention, the contact frames may be attached to a device enclosure for an electronic device in various ways. In an embodiment of the present invention, a frame may be attached to a device enclosure using an insert molded membrane. This insert molded membrane may hold the frame rigidly relative to the device enclosure. In another embodiment of the present invention, a frame may be attached to a device enclosure using a second pliable membrane. This may allow the contact structure to move relative device enclosure. Either the frame or the device enclosure, or both, may have a notch in a face at the frame-to-device interface. The insert molded membrane may have a tab in either or both of these notches. These tabs and notches may secure the frame to the device enclosure such that the frame is not pushed out of the device enclosure when contact is made with a second contact on a second electronic device. In other embodiments of the present invention, the frame may be formed as part of a device enclosure for an electronic device.

Embodiments of the present invention may provide contact structures that may be located in various types of devices, such as portable computing devices, tablet computers, desktop computers, laptops, all-in-one computers, wearable computing devices, cell phones, smart phones, media phones, storage devices, portable media players, navigation systems, monitors, power supplies, adapters, remote control devices, chargers, and other devices. These contact structures may provide pathways for signals and power compliant with various standards such as one of the Universal Serial Bus (USB) standards including USB Type-C, High-Definition Multimedia Interface® (HDMI), Digital Visual Interface (DVI), Ethernet, DisplayPort, Thunderbolt™, Lightning™, Joint Test Action Group (JTAG), test-access-port (TAP), Directed Automated Random Testing (DART), universal asynchronous receiver/transmitters (UARTs), clock